Mitsuo SUZUKI* **Two new species of nyssaceous fossil woods from the Palaeogene of Japan**

鈴木三男*: 日本の古第三紀産ヌマミズキ科2種の材化石

(Plates III–IV)

Since the first report of the fossil wood of the Nyssaceae from the Tertiary of Hokkaido by Mädel (1959), there have been two reports of nyssaceous fossil woods, one from North America (Prakash and Barghoorn 1961) and the other from Netherlands (Van der Burgh 1964). Recently, the present author studied fossil woods belonging to the Nyssaceae, a new species of *Nyssoxylon* from the Palaeogene of Hokkaido and a new species of *Camptotheca* from also the Palaeogene of Kyushu. The new *Nyssoxylon* clearly differs from the recent and the already reported fossil species, and the new *Camptotheca* also differs from the recent species. This is the first report of fossil wood which is referred to *Camptotheca* in the world.

The author was indebted to Associate Prof. Dr. Ken Shimaji and Prof. Dr. Satoru Kurata, University of Tokyo for their precious advices and criticisms in the course of study. He is very grateful to Prof. Dr. Makoto Nishida who kindly permitted to utilize his Laboratory of Phylogenetic Botany, Faculty of Sciences, Chiba University for the present study and to deposit the type specimens in the fossil collection of the same laboratory. Gratitudes are also due to Prof. Dr. Toshimasa Tanai, Hokkaido University and Dr. Shojiro Iwabori, Geological Survey of the Hokkaido Colliery and Steamship Co. Ltd. for their kind offer of fossil specimens.

Camptotheca kyushuensis sp. nov. (Fig. 1. Pl. III.)

Material. No. 71225 (Holotype) : a specimen of silicified, mature secondary xylem measuring about 5×4×4 cm ; the preservation of internal structure is fairly good ; collected by the present author among the gravels on the sea shore of Tsuyazaki in March, 1969. Holotype is deposited in Laboratory of Phylogenetic Botany, Faculty of Sciences, Chiba University.

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Locality: Northern part of Koinoura, Tsuyazaki-machi, Munakata-gun, Fukuoka Prefecture, Kyushu.

Horizon: Tsuyazki Formation, Oligocene, Tertiary (Okada and Obata 1964).

Description. Wood diffuse porous. Growth rings distinct, delineated by the several layers of flattened fiber-tracheids and wood parenchyma; width 1.3–2.5 mm. Pores evenly distributed and numerous (110–140 per square mm); solitary or 2 to several (up to 9) in multiple; multiple pores in radial, oblique or tangential lines, or in clusters; solitary pores mostly oval and sometimes rectangular to polygonal with round corners, 25–70 (average 50) and 40–100 (average 71) μm in tangential and radial diameters

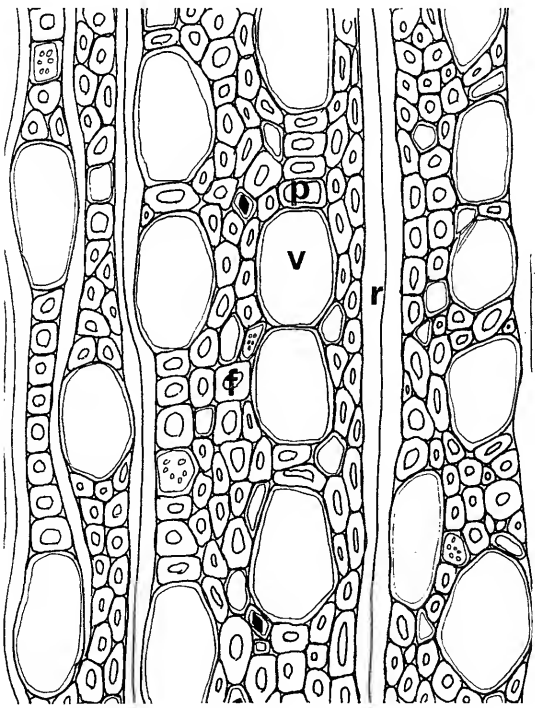

Fig. 1. Cross section of ***Camptotheca kyushuensis*** sp. nov. (No. 71225), showing vessels (v), thin-walled wood parenchyma (p), thick-walled fiber-tracheids (f) and rays (r). ×200.

respectively; thin-walled.

Vessel elements 700–1270 (average 930) μm long; end walls steeply or very steeply oblique with ligulated ends; perforation plates mostly scalariform and sometimes reticulate with 11–37, mostly 18–29 (average 23) thin bars at intervals of 4–7 μm. Intervessel pits alternate or transitional to opposite; oval or horizontally elongated elliptical, 4–5 μm in vertical diameter and mostly 5–7, up to 20 μm in horizontal diameter; aperture linear. Spiral thickenings invisible. Thin-walled tyloses sometimes present and gum-like dark deposit rarely present.

Fiber-tracheids constitute the ground mass of the wood; squarish to polygonal in outline and 10–30 μm in diameter; 2–6, sometimes up to 10 μm in wall thickness; pits small and arranged in a spaced vertical row with slit-like apertures; spiral thickenings invisible.

Wood parenchyma scanty apotracheal diffuse; cells squarish to polygonal in outline, 10–30 μm in diameter and 100–180 μm in length; pits small and crowded in round areas; crystalliferous elements in long vertical series often present in late wood (4–20 or more crystals in a vertical row).

Rays numerous (mostly 9–12 rays per mm); apparently heterogeneous; uni- or biseriate and very rarely triseriate. Uniseriate rays consisting wholly of upright or square cells; 1–8 cells and 60–300 μm high. Multiseriate rays consist of procumbent cells with uniseriate wings of mostly 1–5, up to 9 or more upright or square cells. Procumbent cells oval to polygonal in tangential view and 7–20, 10–25 and 60–150 μm in tangential, vertical and radial diameters respectively; upright or square cells triangular or rectangular in tangential view, 10–25, 25–60 (up to 85) and 20–50 μm in tangential, vertical and radial diameters respectively. Ray-vessel pits resemble intervessel pits in shape and arrangement, but slightly smaller (3–5 μm in diameter). Crystalliferous elements rarely present in the marginal rows.

Nyssoxylon ishikariense sp. nov. (Fig. 2, 3. Pl. IV.)

Material. No. 362001 (Holotype): a large fragment of a fairly large trunk, measuring about 30×20 cm in diameters and 25 cm in height; the preservation of internal structure is fairly good, but often compressed tangentially; collected by Shojiro Iwabori in August, 1962. No. 372008: a set of preparations which were presented by Toshimasa Tanai; the preservation

of internal structure is fairly good. Holotype is deposited in Laboratory of Phylogenetic Botany, Faculty of Sciences, Chiba University.

Locality: No. 362001: Rokuji, Utashinai, Hokkaido. No. 372008: Mayachi, Yubari, Hokkaido.

Horizon: Nos. 362001 and 372008: Yubari Formation, Ishikari group, Eocene, Tertiary.

Description. Wood diffuse porous. Growth rings fairly distinct, delineated by the several layers of flattened fiber-tracheids and wood parenchyma; width 5–7.5 mm. Pores evenly distributed and numerous (80–120 per square mm); solitary or 2 to 5 (up to 10) in multiple; multiple pores in radial, oblique or tangential lines, or in clusters; solitary pores rectangular to polygonal with round corners, 40–80 (average 60) and 50–120 (averge 87) μm in tangential and radial diameters respectively; thin-walled.

Vessel elements 740–1450 (average 1075) μm long; end walls very steeply oblique with ligulated ends; perforation plates mostly scalariform and sometimes reticulate with numerous thin bars (mostly 30–50, average 41 bars) at very narrow intervals; several scalariform bordered pits present at the upper and lower side of perforation plates. Intervessel pits mostly opposite with the tendency to scalariform or alternate arrangements; horizontally elongated rectangular or elliptical, 5–7 and 6–50 μm in vertical and horizontal diameters respectively; apertures elliptical or linear. Spiral thickenings invisible and thin-walled

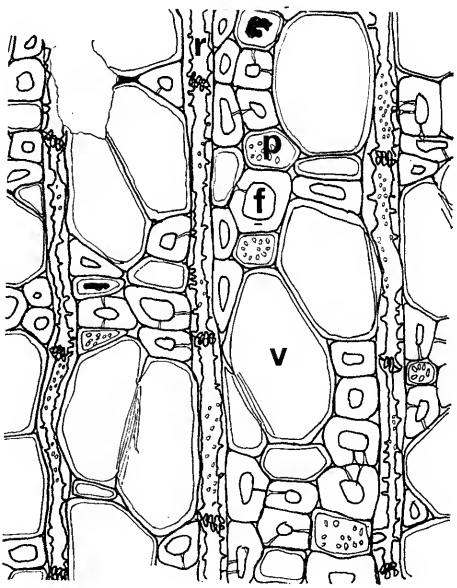

Fig. 2. Cross section of *Nyssoxylon ishikariense* sp. nov. (No. 362001), showing vessels (v), thin-walled wood parenchyma (p), thick-walled fiber-tracheids (f) and rays (r). ×240.

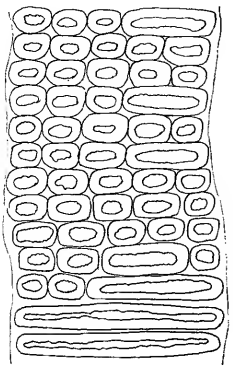

Fig. 3. Intervessel pits of *Nyssoxylon ishikariense* sp. nov. (No. 362001), showing opposite or scalariform arrangements. ×500.

tyloses abundant.

Fiber-tracheids constitute the ground mass of the wood; squarish to polygonal in outline, 8-45 μm in diameter; 4–7 μm in wall thickness; pits small circular and arranged in a spaced vertical row with slit-like apertures; spiral thickenings invisible.

Wood parenchyma scanty apotracheal diffuse; cells squarish to polygonal in outline, 15–30 μm in diameter and mostly 100–180 μm in length; pits to vessels spaced, round and small; interparenchyma pits very small and crowded in round areas; crystalliferous elements invisible.

Rays numerous (10–15 rays per mm); almost homogeneous with the tendency to heterogeneous; becoming heterogeneous at injured parts; mostly uniseriate and sometimes biseriate partially or entirely; consisting of procumbent cells with one or several marginal layers of square cells. Procumbent cells 12–25 (average 19), 17–27 (average 23) and 80–200 μm in tangential, vertical and radial diameters respectively; square cells 35–40 and 30–65 μm in vertical and radial diameters respectively, and hardly recognised in tangential section; horizontal and tangential walls very thick and densely pitted with very small pits. Ray-vessel pits somewhat smaller than intervessel pits; oval or horizontally elongated elliptical with linear apertures. Crystalliferous elements invisible.

Affinity and discussion

The most outstanding features of the present fossils are as follows: (1) pores are diffuse, numerous and moderately small, and solitary or in multiple, (2) perforation plates are exclusively scalariform with many bars and (3) rays are narrow (less than 3 cells wide). In the course of study, it was very difficult to determine the affinitive taxonomic group of the

present fossils, because very numerous representatives among dicotyledonous woods show such features. According to Metcalfe and Chalk (1950), the following 9 families show the above mentioned features: Myrotamnaceae, Octoknemaceae, Eucryphiaceae, Fagaceae, Magnoliaceae, Monimiaceae, Cercidiphyllaceae, Betulaceae and Nyssaceae. Among these eligible 9 families, the Myrotamnaceae and the Octoknemaceae may be cut off from the candidates for the lack of wood parenchyma. The Eucryphiaceae may be also cut off for the abundance of parenchyma, which sometimes shows terminal arrangement. In the Fagaceae, only *Nothofagus* shows the resemblance to the present fossils, but it is also disqualified as a candidate, because it has fewer bars in perforation plates. In the Magnoliaceae, only *Magnolia* and *Talauma* show the above mentioned features, but their perforation plates have fewer bars (less than 25 bars). Intervessel and ray-vessel pits of the Monimiaceae are predominated by scalariform type. The Cercidiphyllaceae much resembles the present fossils in many features, but it also should be cut off because the pores of the Cercidiphyllaceae are smaller and almost solitary, and the rarely occurring intervessel pits of it show apparently scalariform arrangement. Among the Betulaceae, certain members of *Alnus* which lack aggregate rays, mostly belonging to Section Alnobetula, resemble the present fossils. Among the present fossils, No. 71225, having distinct heterogeneous and uni- or biseriate rays, apparently differs from such members of *Alnus* which have homogeneous and mostly uniseriate rays. The other two fossils, Nos. 362001 and 372008, coincide with such members of *Alnus* in many features. But the former also has some differences from the latter as follows: (1) perforation plates of Nos. 362001 and 372008 have many bars (20–60 bars) while those of *Alnus* have fewer bars (mostly less than 30 bars), (2) intervessel pits of the former are larger and somewhat spaced mostly in opposite or scalariform arrangement while those of the latter are very small and dense mostly in alternate arrangement, and (3) ray-vessel pits of the former are rather sparse (less than 20 pits per ray cell) while those of the latter are many (40–60 or more pits per ray cell) (Hall 1952). Thus, the present fossils have little affinity even with *Alnus*.

On the other hand, certain members of the last named family, the Nyssaceae, agree well with the present fossils in many anatomical features.

There are three genera of the Nyssaceae : *Nyssa* is distributed in East Asia (2 spp.) and North America (5 spp.), and monotypic genera *Davidia* and *Camptotheca* in China (Eyde 1963). *Nyssa* and *Davidia* closely resemble each other in anatomical features, but *Camptotheca* differs from these two genera in some distinct features as follows: (1) *Nyssa* and *Davidia* have very numerous bars in perforation plates (more than 20, sometimes up to 100 or more bars) while *Camptotheca* has only 16–30 bars, (2) the former two often have scalariform bordered pits at the upper and lower side of perforation plates, while such pits seldom occur in the latter, and (3) intervessel pits of the former two are mostly arranged in opposite and sometimes in scalariform, while those of the latter mostly in alternate (Metcalfe and Chalk 1950, Tang 1930, Brown and Panshin 1940, and Pearson and Brown 1932). Comparing with the Nyssaceae, it becomes clear that No. 71225 closely resembles *Camptotheca* while Nos. 362001 and 372008 resemble *Nyssa* or *Davidia*.

The monotypic recent species *Camptotheca acuminata* Decne. much resembles No. 71225 in many anatomical features such as the number of bars, heterogeneous rays and the occurrence of crystalliferous elements. But there are some minor differences between them : triseriate rays are common in the recent species while rare in this fossil; solitary pores rather sparse in the former while fairly numerous in the latter; and intervessel pits typically alternate in the former while with some tendency to be opposite in the latter. Tang (1930) reported the occurrence of spiral thickenings in vessels of *C. acuminata*, but the present author could not observe them in a wood specimen of this species (TOFOw No. 10840) as well as in this fossil. Thus, No. 71225 should be surely a member of *Camptotheca*, which is closely related to the recent species. As far as the present author knows, there are no reports of fossil woods which are related to *Camptotheca*. Accordingly, he offers the name *Camptotheca kyushuensis* for the present fossil.

On the other hand, Nos. 362001 and 372008 agree with *Nyssa* or *Davidia* in most anatomical features except the homogeneity and width of rays. Namely, the former two have almost homogeneous and uniseriate rays, while no recent species of the latter possess such rays. But, in certain recent species, especially in *N. aquatica*, rays undoubtedly show the tendency to become homogeneous and narrower. Conversely, typically heterogeneous

rays appear in the injured parts of No. 362001. Thus, the present fossils should be a member of *Nyssa* or *Davidia*, although they seem to be different from any recent species.

Fossil woods of the Nyssaceae were reported for the first time by Mädel (1959) on the basis of the preparations of Reiss, on which the latter had identified them as *Betulinium Macclintockii* Cram. (1907). Mädel re-examined those preparations and treated them as a new species closely related to *Nyssa* or *Davidia*, describing under the name of new form genus as *Nyssoxylon japonicum*, because the anatomical features of *Nyssa* and *Davidia* much resemble each other. The specimen of *Nyssoxylon japonicum* was obtained from Ombetsu river, Kushiro, Hokkaido and the horizon was inferred as the Tertiary (Reiss 1907 and Mädel 1959). This inference must be right, and if it is permitted for the present author to infer still more, the horizon of this specimen may be the Palaeogene. The present fossils, Nos. 362001 and 372008 are also obtained from the Palaeogene of Hokkaido and they show the close resemblance to *N. japonicum*, but differ in the homogeneity, the width of rays, and some other features. On the other hand, Prakash and Barghoorn (1961) reported a new fossil wood of *Nyssa*, *N. eydei*, from the Miocene of North America. But, *N. eydei* also differs from the present fossils by the presence of crystalliferous elements, heterogeneous and wider rays. Moreover, Van der Burgh (1964) discovered a *Nyssoxylon*, *N. haanradense*, from the Miocene of Netherlands. Also it is apparent that *N. haanradense* differs from the present fossils by the common presence of crystalliferous elements and wider rays. Thus, the present fossils are certainly a new member of *Nyssoxylon*, and the present author offers the name *Nyssoxylon ishikariense* for them, as the specimens were discovered from the Ishikari coal field.

From the Tertiary of Hokkaido, Reiss also described *Alnoxylon jezoensis* (1907). Its anatomical features may be summarised as follows: diffuse porous wood with numerous and small, often multipled pores; perforation plates exclusively scalariform with 25–30, sometimes up to 40 or more bars (in the reobservation by Müller-Stoll and Mädel 1959, bars were countered as 26–50); intervessel pits opposite (also Müller-Stoll and Mädel reobserved that they showed the tendency to scalariform); rays almost heterogeneous and uniseriate; ray-vessel pits numerous (about 20 pits per ray cell); no

aggregate rays. As previously mentioned, wood of *Alnus* are distinguishable from that of *Nyssa* or *Davidia* by fewer bars, mostly alternate arrangement of intervessel pits, the more numerous ray-vessel pits, and occurrence of aggregate rays in many species. Apparently, it should be difficult to regard Reiss' fossils as an affinitive member of *Alnus* (Müller-Stoll and Mädel 1959), and it may be more natural to regard it as a member of the Nyssaceae. Moreover, the occurrence of uniseriate rays and opposite to scalariform arrangement of intervessel pits in his fossils may indicate the resemblance to *Nyssoxylon ishikariense*. Anyhow, it is very difficult for the present author to make clear the affinity of Reiss' species, as his description and illustrations are not fully available for comparing them.

Although fossil records of the Nyssaceae are abundant in Europe and North America, those are rather poor in Japan, and restricted to the Neogene except woods (Eyde and Barghoorn 1963). On the basis of the leaf, the only one species, *Nyssa japonica*, was reported from the Miocene of Hokkaido (Tanai and Suzuki 1963). On the endocarp, Miki (1956) described three species of *Nyssa* from the Pliocene of Honshu and Kyushu, and Kokawa (1965) reported *Davidia involucrata* Baill. also from the Pliocene of Kanagawa Prefecture. On the other hand, it became apparent on the basis of the wood that at least three species of the Nyssaceae were present in the Palaeogene of Japan, one in Kyushu and the other two in Hokkaido, as discussed above. Thus, it may be said that the representatives of the Nyssaceae had grown throughout the Tertiary Period in Japan and exterminated at the beginning of the Quaternary Period.

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北海道及び九州の古第三紀層から得られた材化石より，ヌマミズキ科の2新種を記載した。ヌマミズキ科の材化石は，1959年に Mädel が北海道第三紀産の化石で *Nyssoxylon japonicum* を記載したのが世界最初で，以後北米の中新世から *Nyssa eydei* Prakash et Barghoorn が，オランダの中新世から *Nyssoxylon haanradense* Van der Burgh が報告されているのみである。北海道の空知及び夕張の始新世の地層より得られた珪化木は，基本的な材構造においては現生の *Nyssa, Davidia* 両属に一致するが，放射組織がほぼ同性で，また幅がほとんど単列であることから，全ての現生及び化石種から明確に区別することができるので *Nyssoxylon ishikariense* として記載した。一方，福岡県津屋崎の海岸より得た珪化木は，現生の *Camptotheca* 属に基本的構造はよく一致するが，いくつかの点で明らかに異なるので *C. kyushuensis* として記載した。筆者の知る限りでは *Camptotheca* 属の化石の報告は，世界のいかなる地域，時代からも報告がなく，これが初めてと思われる。日本の新第三紀からは *Nyssa* の葉が，また *Nyssa* 及び *Davidia* の内果皮が知られており，ヌマミズキ科は日本で

は第三紀を通して分布していたが，第三紀末に全て絶滅したと考えられよう。

Explanation of Plates III–IV

Plate III　*Camptotheca kyushuensis* sp. nov. (No. 71225): A, cross section ×40. B, tangential section ×100. C, tangential section showing two series of crystalliferous elements in wood parenchyma ×200. D, radial section showing two scalariform perforation plates with about 20 bars ×400. E, radial section showing alternately arranged intervessel pits ×400. F, radial section showing intervessel pits on two vessels ×100. G, radial section showing circular ray-vessel pits ×200.

Plate IV.　*Nyssoxylon ishikariense* sp. nov. (No. 362001): A, cross section ×20. B, tangential section ×100. C, cross section showing an annual ring boundary ×40. D, radial section showing scalariform perforation plates with numerous bars ×120. E, radial section showing circular to horizontally elongated elliptical ray-vessel pits ×240.

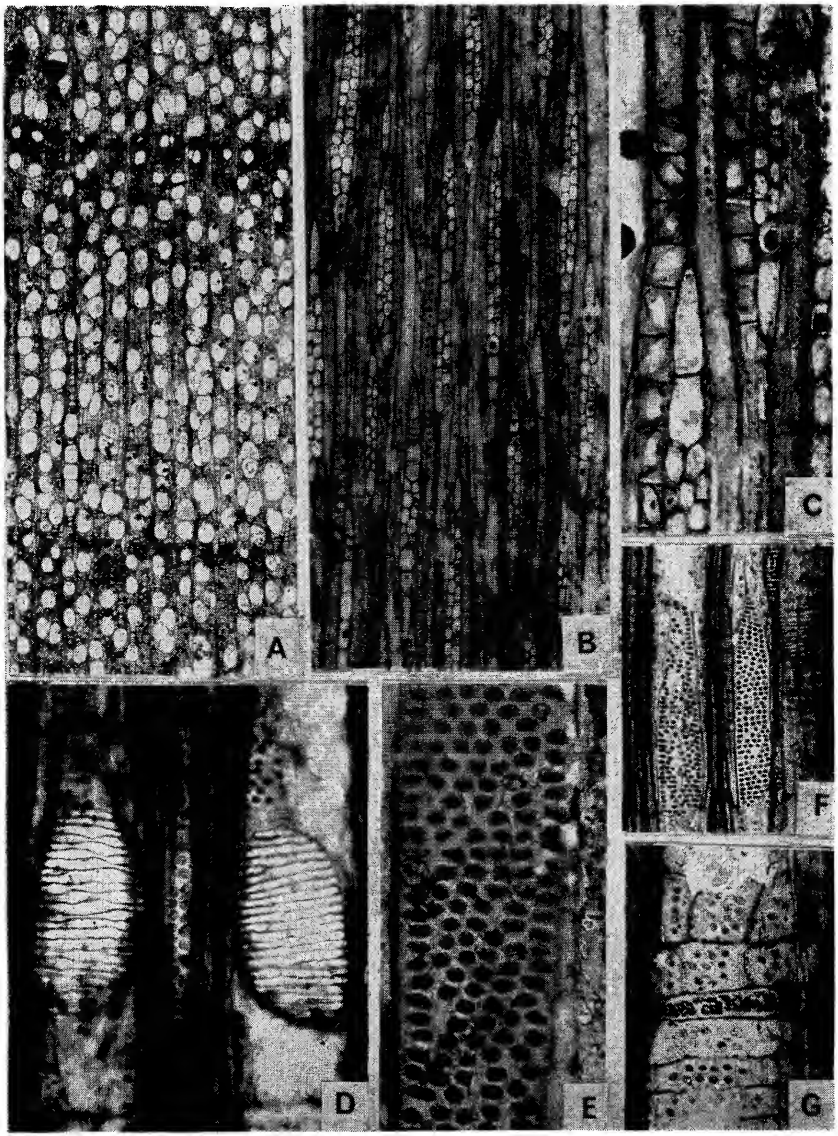
○新らしく日本に帰化したアメリカネナシカズラ(新称)について（浅井康宏）
Yasuhiro Asai: On a North American dodder, *Cuscuta pentagona* Engelmann, newly established in Japan

かねてから東京を中心とした各地の河原（河川敷），堤防，海浜などに，ハマネナシカズラに類似の種類が多産し，これの所属について問題視されていた。

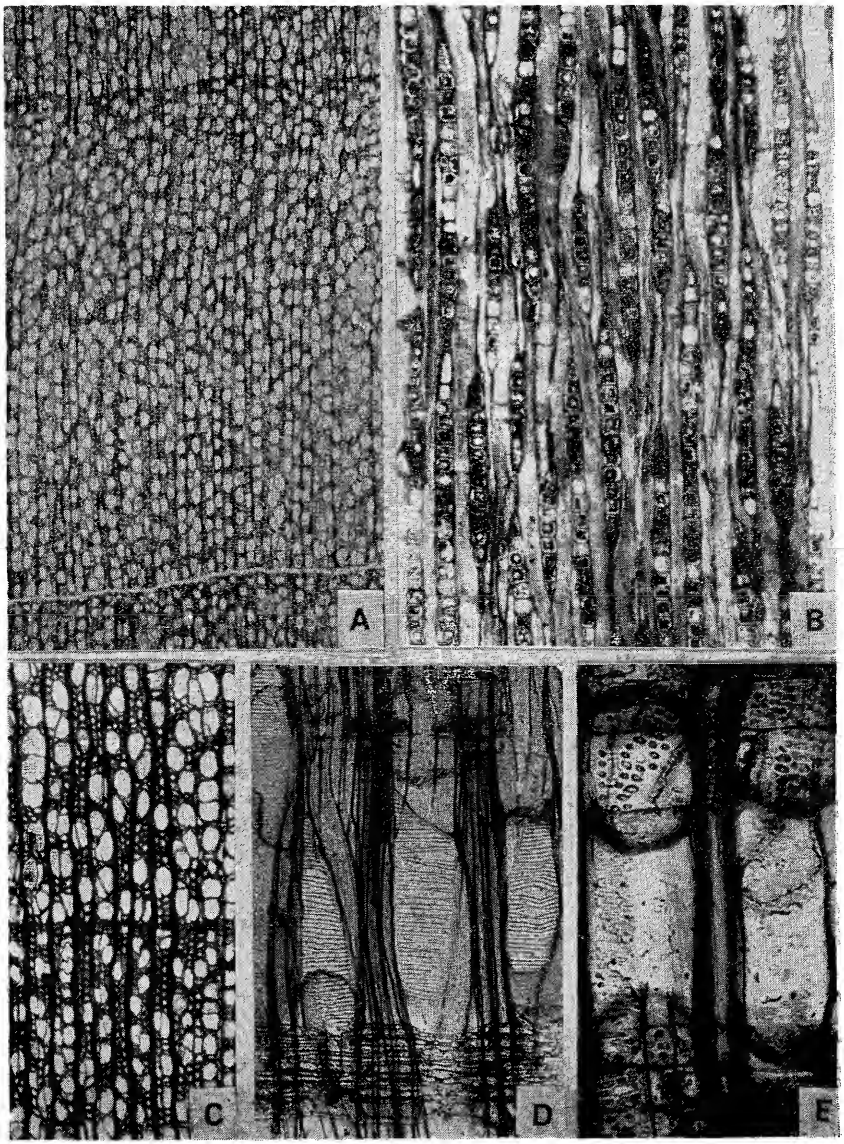
筆者自身も一昨年（1973）8月に静岡県下の新設道路周辺その他で，これと同様のものを実見し，生品について詳細な観察を加えることができた。一方，東京都府中市近傍の植物について鋭意調査を進めておられる飯泉　優，曾根伸典氏らは，1970年頃より多摩川流域での本属 *Cuscuta* 植物の異常繁殖状況に注目し，これをマメダオシあるいはハマネナシカズラとして取扱い，報告されていた。しかしながら曾根氏は，これらに対して更に一層詳細な検討を加えた結果，我国における既知種とも異ったものであるとの見解に達すると共に，筆者にその正確な検定と解決方を促された。

筆者も各地から寄せられた資料や生育分布状態，寄主ならびに現地における生品の観察結果などから，本種は本来の自生種ではなく，明らかに我国へ近年侵入した帰化植物であるとの確信を得，一応これをヨウシュネナシカズラと仮称し，関係諸氏に披歴しておいた。

しかし周知の通り，この属のものは可成り多くの種類を含み，しかも侵入源として最も関聯深いと思われる北アメリカには類似の種類も多く，従って本種の我国での解決に少なからず危惧の念を抱かざるを得なかった。



M. SUZUKI: Nyssaceous fossil woods



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